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ABSTRACT

This document, which lists the biotechnology competencies identified by representatives from biotechnology businesses and industries as well as secondary and post-secondary educators throughout Ohio, is intended to assist individuals and organizations in developing college tech prep programs that will prepare students from secondary through post-secondary associate degree programs for employment as technicians in the biomedical, environmental, pharmaceutical, and other biotechnology related industries, such as bioinformatics. The technical competencies are listed in the following categories: demonstrate scientific method; conducting experiments; laboratory safety and maintenance; instrument analysis; chemical materials handling and sampling; physical properties measurement; biohazard storage, handling, and disposal; basic microbiology; biochemical technology; molecular biology technology; cell culturing; protein bioseparation methods; fermentation technology; microbiology for biotechnology; bioethics; water and wastewater treatment operations; environmental science; environmental assessments; introduction to industry; technical writing and documentation; computer applications for biotechnology; and a bioinformatics strand for database administration, data warehousing, and statistics. The competencies, which are separated into essential competencies needed to ensure a minimal level of employability and recommended competencies, are organized by instructional units and include suggestions as to when students should be introduced to and proficient at them. Appendices include a list of technical competency profile (TCP) panel members and a pathway template. (MO)

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OHIO BIOTECHNOLOGY COMPETENCY PROFILE

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CE 085 382

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INTRODUCTION

The Ohio Biotechnology Technical Competency Profile was developed under the auspices of the Ohio Board of Regents and the Ohio Department of Education. It provides a framework for a broad-based educational response to Ohio's need for a skilled biotechnology workforce.

The profile includes a comprehensive set of competencies that are grounded in core academic subject areas and focuses on occupations for technicians in the biomedical, environmental, pharmaceutical, and other biotechnology related industries, such as bioinformatics. Generated using the Ohio Tech Prep model for curriculum development, the profile reflects the job opportunities and skills required for Ohio's biotechnology workers. With the future of health care, agriculture and industrial processes gravitating toward biotechnology, industries position biotechnology as the catalyst for their economies.

Four Tech Prep Consortia were selected to pilot the biotechnology curriculum by partnering with secondary, postsecondary and businesses. Pilot sites represented diversity in being urban, rural, and suburban populations. Participating Tech Prep consortia were located at Sinclair Community College in Dayton, Lakeland Community College in Kirtland, Kent State University/Trumbull Campus in Warren, and Cuyahoga Community College in Cleveland. Representatives from biotechnology businesses and industries played a critical role in assisting Ohio Tech Prep define the vision and scope for the curriculum and by identifying the essential and recommended skills for current and future biotechnology professionals. Secondary and post-secondary educators representing schools and colleges in the four consortia identified when in the educational process and to what depth those skills identified by business should be addressed. The curriculum will be updated and/or expanded after the initial year of piloting.

The Biotechnology Technical Competency Profile will be used as the basis for development of an integrated delivery system that provides opportunities for new and challenging programs and courses in Ohio's secondary schools, colleges, and universities. Career-Technical Education, Tech Prep, and adult education will be enhanced and expanded through the use of the biotechnology curriculum.

This profile is available on the Internet at: www.ohtpcs.org. At this location, users can download copies of the entire profile, or by units or conduct searches on a number of key variables. For additional information contact:

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Thanks are also due to the following:

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TABLE OF CONTENTS

College Tech Prep ix

Key to Profile Codes xi

Ohio Biotechnology General Information xiii

Ohio Biotechnology Program Profile xv

Ohio Biotechnology Curriculum Matrix xvi

Biotechnology State Competency Profile 1

Appendices 113

COLLEGE TECH PREP

College Tech Prep is a high school and college career path linked to business, industry, and labor that insures a specified seamless pathway from high school to college to careers, meeting Ohio's technological employment needs.

A College Tech Prep student is enrolled in a state approved Tech Prep education program. A College Tech Prep Program means a program of study that:

- Combines, at a minimum, two years of secondary education (as determined by Ohio definitions) with a minimum of two years of post-secondary education in a non-duplicative, sequential course of study.
- Integrates academic and technical instruction and utilizes work-based and work-site learning, where appropriate and available.
- Provides technical preparation in a career field such as engineering technology; applied science; mechanical, industrial or practical art or trade; agriculture; health occupations; business; or applied economics.
- Builds student competencies in mathematics, science, reading, writing, communications, economics, and workplace skills through applied, contextual academics and integrated instruction, in a coherent sequence of courses.
- Leads to an associate or baccalaureate degree, or a BAT (Bureau of Apprenticeship Training) apprenticeship requiring a minimum of two years in a specific career field.
- Leads to placement in appropriate employment or to further education.

KEY TO PROFILE CODES

IMPORTANCE OF COMPETENCIES

All of the competencies in this document represent the minimum requirements for a College Tech Prep engineering technologies program. It is the responsibility of the local consortia to further define and/or expand the key indicators for each competency, as needed. Each competency will be taught at either the introductory or proficiency level by the completion of the Tech Prep program, which is the minimum of an Associate Degree.

The intent of this document is to integrate high academics with skill acquisition. Technical skills are a required component. However, the degree of skill acquisition may vary based on the educational setting.

I = **Introduce** (Learner will demonstrate knowledge and comprehension of the competency.)

P = **Proficient** (Learner will demonstrate ability to apply knowledge of and/or perform the competency.)

R = **Recommend** (The unit or competency is only recommended at this time.)

Grade Level: **12** = by the end of grade 12
AD = by the end of the Associate Degree

All essential competencies have been assigned a P (Proficient) by end of the Associate Degree. [There may be instances where both Introduce and Proficient are at either the 12th grade or the Associate Degree.]

ACADEMIC CONNECTION (AC)

All Tech Prep programs are responsible for meeting the academic content standards that are referenced in the appendix of this document.

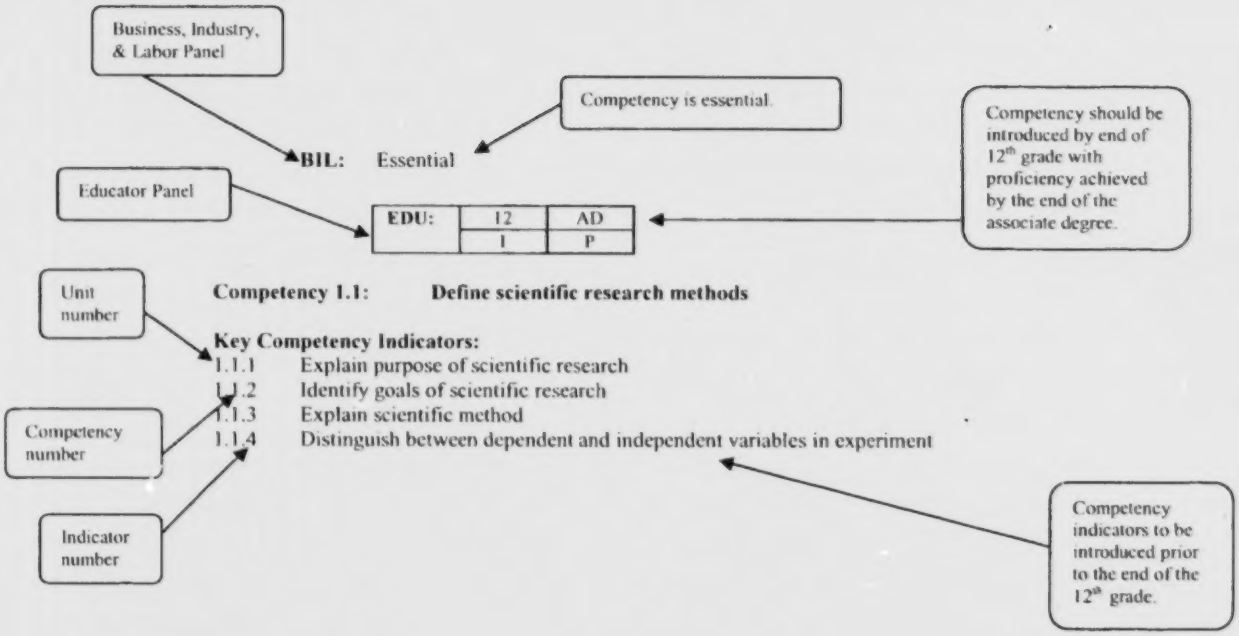
Example:

BIL: Essential

EDU:	**12**	**AD**
	I	P

Competency 1.1: Analyze . . . .
Key Competency Indicators:
Explain . . . .
Identify . . . .

EXAMPLE:


Business, Industry, & Labor Panel
Competency is essential.
Competency should be introduced by end of 12th grade with proficiency achieved by the end of the associate degree.
BIL: Essential
Educator Panel
EDU: 12 AD
I P
Unit number
Competency 1.1: Define scientific research methods
Key Competency Indicators:
1.1.1 Explain purpose of scientific research
1.1.2 Identify goals of scientific research
1.1.3 Explain scientific method
1.1.4 Distinguish between dependent and independent variables in experiment
Competency number
Indicator number
Competency indicators to be introduced prior to the end of the 12th grade.

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OHIO BIOTECHNOLOGY GENERAL INFORMATION

Biotechnology defined: The knowledge of bioprocesses applied to the engineering and use of organisms, cells or biomolecules to solve problems or make products.

Biotechnology programs prepare people to work in the bioscience industry in the areas of research and development, quality systems, production, clinical testing, and diagnostic work.

Biotechnology Technician: An individual who may prepare materials, conduct experiments, record data, and assist with the development and presentation of reports. Occupations may include, but **not** limited to:

- Quality control/assurance technician
- Fermentation technician
- Tissue culture technician
- Laboratory assistant
- Microbiology technician
- Molecular biology technician
- Data analyst
- Manufacturing technician
- Development/research technician

Graduates of community college biotechnology programs may obtain entry level work in the bioscience industry and may advance rapidly with on-the-job experience and continued academic work.

Bioinformatics defined: Bioinformatics is an area of science that incorporates computation approaches to solving biological problems. Bioinformatics is the application of mathematics (e.g., probability and statistics), science (e.g., biochemistry), and a set of problem solving methods (e.g., computer use and programming) to design and implement solutions to critical problems. The field is rapidly evolving and growing. New methods of storing and accessing data are needed for scientists to make efficient use of data. Bioinformaticists must organize a phenomenal amount of biological sequence information and make available to other scientists around the world. Jobs are available in Biotechnology laboratory settings.

OHIO BIOTECHNOLOGY PROGRAM PROFILE

Baccalaureate (14-16)

Postsecondary

Ohio Biotechnology Technical Competency Profile

Bio-Tech/Instrumentation

Informatics

Genetics
Cellular Biology
Chemistry
Laboratory Skills and Procedures

Data Mining
Databases
Spreadsheets
Web
Technical Report Writing
Statistics

Algebra, Technical Math, Chemistry, Biology, Communications, Anatomy/Physiology, Computing

Secondary

OHIO BIOTECHNOLOGY CURRICULUM MATRIX

BTT =	Biotechnology Technician with Laboratory Research and Environmental focus and introduction to occupation for Bioinformaticists		
Page #	Unit #	Unit	BTT
1	1	Demonstrate Scientific Method	E
5	2	Conducting Experiments	E
7	3	Laboratory Safety and Maintenance	E
13	4	Instrument Analysis	E
19	5	Chemical Materials Handling and Sampling	E
21	6	Physical Properties Measurement	E
23	7	Biohazard Storage, Handling, and Disposal	E
27	8	Basic Microbiology	E
31	9	Biochemical Technology	E
41	10	Molecular Biology Technology	E
47	11	Cell Culturing	E
53	12	Protein Bioseparation Methods	E
59	13	Fermentation Technology	E
61	14	Microbiology for Biotechnology	E
63	15	Bioethics	E
65	16	Water and Wastewater Treatment Operations	R
73	17	Environmental Science	R
81	18	Environmental Assessments	R
87	19	Introduction to Industry	E
91	20	Technical Writing and Documentation	E
93	21	Computer Applications for Biotechnology	E
101	22	Database Administration - (Bioinformatics strand)	E
109	23	Data Warehousing - (Bioinformatics strand)	E
113	24	Statistics - (Bioinformatics strand)	E

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Unit 1: Demonstrate Scientific Method

BIL: Essential

EDU:	12	AD	AC
	P	P	

Competency 1.1: **Define scientific research methods**

Key Indicators:

1.1.1 Explain purpose of scientific research
1.1.2 Identify goals of scientific research
1.1.3 Explain scientific method
1.1.4 Distinguish between dependent and independent variables in experiment

BIL: Essential

EDU:	12	AD	AC
	P	P	

Competency 1.2: **Develop research plan**

Key Indicators:

1.2.1 Select research question
1.2.2 Design research plan including significance of problem, purpose, variables, hypothesis, objectives, methods of study, and list of materials
1.2.3 Identify deficiencies of plan

BIL: Essential

EDU:	12	AD	AC
	I/R	P	

Competency 1.3: Apply critical thinking skills

Key Indicators:

1.3.1 Draw conclusions from a set of facts/data
1.3.2 Correlate results and plan needed action
1.3.3 Make comparative judgment from data
1.3.4 Diagnose problems from a set of data and observations
1.3.5 Identify solutions
1.3.6 Interpret data generated for records, files, and reports
1.3.7 Analyze data for accuracy
1.3.8 Decipher ambiguous information or instructions
1.3.9 Integrate information from diverse sources
1.3.10 Recognize own limitations
1.3.11 Recognize and correct discrepancies
1.3.12 Anticipate and assess emergencies
1.3.13 Analyze data retrieved from instrument output
1.3.14 Identify models to interpret scientific phenomena

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 1.4: Demonstrate problem solving skills

Key Indicators:

1.4.1 Recognize existence of problem
1.4.2 Identify possible reasons/causes of problem
1.4.3 Implement plan of action to resolve problem

1.4.4 Evaluate progress of action plan
1.4.5 Revise plan as indicated by findings
1.4.6 Identify components of action plan to resolve problem
1.4.7 Monitor progress of action plan
1.4.8 Apply methods for qualitative and quantitative analysis, data gathering, direct and indirect observations, predictions
1.4.9 Identify ethical dilemmas involved in scientific experimentation

Unit 2: Conducting Experiments

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 2.1: **Perform routine laboratory support work**

Key Indicators:

2.1.1 Maintain laboratory and equipment
2.1.2 Order and stock supplies
2.1.3 Operate equipment
2.1.4 Maintain biological stock cultures
2.1.5 Clean and prepare items for lab
2.1.6 Prepare biological and/or chemical materials
2.1.7 Send, receive, and distribute biological and chemical materials
2.1.8 Perform routine animal care duties
2.1.9 Communicate with co-workers to ensure quality laboratory work

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 2.2: **Conduct experiments**

Key Indicators:

2.2.1 Set up equipment for the production process
2.2.2 Perform and monitor the process to make the product or provide the service
2.2.3 Inspect materials at all stages of process to determine quality or condition
2.2.4 Participate in the installation, modification, and upgrade of equipment
2.2.5 Prepare final product for shipping or distribution

2.2.6 Monitor, maintain, and troubleshoot equipment, tools, and workstation
2.2.7 Communicate with co-workers and/or customers to ensure production of service meets requirements
2.2.8 Coordinate inventory

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 2.3: Record and report experimental results

Key Indicators:
2.3.1 Maintain lab notebook
2.3.2 Identify methods of precision and accuracy of experimental data
2.3.3 Document results of the experiment in q written report using good laboratory practices or other procedures, which include statement of propose, experimental design, results, conclusions, and next steps
2.3.4 Monitor results of an experiment
2.3.5 Maintain log book
2.3.6 Identify components of scientific paper/report
2.3.7 Identify components of oral presentation
2.3.8 Prepare scientific report
2.3.9 Present scientific report orally
2.3.10 Use scientific notation
2.3.11 Recognize that experimental results must be open to scrutiny of others
2.3.12 Demonstrate various ways to display data

Unit 3: Laboratory Safety and Maintenance

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 3.1: **Explain the impact of federal, state, local, and company regulations and policies on safety, health, and environmental concerns of the community, worker, and consumer**

Key Indicators:

3.1.1 Identify the agencies (federal, state, and local) that develop and enforce regulations pertaining to chemical and related industries

3.1.2 State the basic philosophy of "Right to Know" legislation

3.1.3 Use computers and other reference sources to access information about procedures for chemical safety, environmental protection, and health preservation

3.1.4 Describe basic emergency procedures used to respond to a spill or release

3.1.5 Explain material safety data sheets (MSDS)

BIL: Essential

EDU:	12	AD	AC
	P	P	

Competency 3.2: **Demonstrate personal safety procedures**

Key Indicators:

3.2.1 Protect against sight loss in the laboratory environment

3.2.2 Use appropriate personal protective equipment (PPE) for a variety of situations involving hazardous chemicals, such as corrosive, explosive, biological, and volatile materials

3.2.3 Use safety equipment, such as safety glasses, showers, respirators, eye washes, blankets, and portable fire extinguisher
3.2.4 Identify protection from blood-borne pathogens
3.2.5 Maintain a clean and safe workplace
3.2.6 Perform basic first aid skills
3.2.7 Participate in employee safety training
3.2.8 Monitor air quality in a workplace using a variety of types of air monitoring equipment
3.2.9 Identify unsafe conditions and take corrective action

BIL: Essential

EDU:	12	AD	AC
	P	P	

Competency 3.3: Identify general workplace safety hazards

Key Indicators:
3.3.1 Identify first aid supplies, personnel, co-worker contact, medical information, emergency protection and evacuation plan
3.3.2 Follow appropriate safety procedures, guidelines, and chemical hygiene plan
3.3.3 Maintain required safety training to include location and understanding of MSDS
3.3.4 Observe rules of equipment safety
3.3.5 Comprehend and obey safety symbols/signs
3.3.6 Keep work areas free from clutter, food, and drinks
3.3.7 Recognize common lab hazards and observe procedures for the safe use of instruments, gas cylinders, and chemicals
3.3.8 Utilize safety equipment and personal protection equipment
3.3.9 Handle common chemical lab equipment safely
3.3.10 Describe the purpose of common chemical laboratory equipment
3.3.11 Manipulate glassware and other apparatus safely, including making connections, cleaning, and storing
3.3.12 Demonstrate a basic awareness of electrical safety and its application to the work environment

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 3.4: Handle laboratory equipment safely

Key Indicators:

3.4.1 Store compressed gases cylinders correctly and safely
3.4.2 Change compressed gas cylinders correctly and safely
3.4.3 Choose the proper regulations for gases and other materials under pressure or under vacuum
3.4.4 Use equipment such as autoclaves, pressurized reactors, thermal ovens, vacuum reactors/separators, closed systems, and a variety of valves safely
3.4.5 Demonstrate use of safety equipment
3.4.6 Maintain safety equipment

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 3.5: Handle chemicals and safety equipment appropriately

Key Indicators:

3.5.1 Use appropriate safety equipment (e.g., proper hoods, shields)
3.5.2 Identify hazards associated with collecting samples
3.5.3 Label and store all chemicals, materials, tools, and equipment with appropriate safety, health, and environmental details
3.5.4 Follow the hazard symbols and toxicology sections of material safety data sheets (MSDS)
3.5.5 Demonstrate the ability to read, interpret, and prepare labels for a variety of chemical materials

3.5.6 Use a chemical reference handbook to identify hazards associated with handling and storing chemical materials
3.5.7 Handle corrosive materials properly
3.5.8 Use appropriate techniques to transfer gases, liquids, and solids from storage containers to equipment used in laboratory
3.5.9 Use mixing techniques appropriate for the materials, specifically when handling acids, bases, oxidizers, and strong reducing agents
3.5.10 Dispose of hazardous materials safely and according to regulatory guidelines
3.5.11 Order and stock supplies
3.5.12 Implement a chemical inventory system for a stockroom that includes all pertinent information regarding stability, hazards, and sensitivity
3.5.13 Use (enter into and query out of) a database for chemical information

BIL: Essential

EDU:	12	AD	AC
	I	R	

Competency 3.6: Respond to medical emergencies

Key Indicators:
3.6.1 Perform head to toe assessment
3.6.2 Describe signs and symptoms of emergency situations
3.6.3 Identify basic emergency procedures and equipment
3.6.4 Contact local emergency assistance
3.6.5 Demonstrate first responder procedures
3.6.6 Identify évacuation techniques

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 3.7: Describe laboratory safety and biohazard issues

Key Indicators:

3.7.1 Outline elements of risk assessment
3.7.2 Name the typical general safety hazards in tissue culture laboratory
3.7.3 Explain proper level of protection for various biohazard procedures
3.7.4 Describe proper disposal procedures for tissue culture materials
3.7.5 Monitor usage and exposure of radioisotopes and biohazards

Unit 4: Instrument Analysis

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 4.1: **Demonstrate proficiency in the use of pipeting devices, microwave, scales, and pH meters**

Key Indicators:

4.1.1 Perform measurements using the metric system
4.1.2 Describe the use of pipeting devices for accurate volume measurements
4.1.3 Explain the pH scale
4.1.4 Check calibration of pipeting devices, scales, and pH meters

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 4.2: **Apply principles of filtration**

Competency Builders:

4.2.1 Filter sterilize a solution
4.2.2 Filter solutions using depth and membrane filters
4.2.3 Choose proper filter for an application
4.2.4 Describe ultrafiltration

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 4.3: **Perform sedimentation and separation of biological materials using centrifuges**

Key Indicators:

4.3.1 Explain revolutions per minute (RPM), centrifugal force, differential centrifugation, and density gradient centrifugation
4.3.2 Run high speed centrifuge
4.3.3 Run ultracentrifuge
4.3.4 Separate materials by gradient centrifugation
4.3.5 Separate cell components by centrifugation

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 4.4: **Demonstrate proficiency in use of the common types of microscopes (e.g., light microscope, phase contrast microscope)**

Key Indicators:

4.4.1 Examine biological specimens using microscopes
4.4.2 Demonstrate understanding of the principles of microscopy
4.4.3 Process specimen for light microscopy

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 4.5: **Demonstrate proficiency in use of the ultraviolet-visible (UV/visible) spectrophotometer, and construct standard curves**

Key Indicators:

4.5.1 Obtain a and interpret absorption/transmission data for biological samples

4.5.2 Construct a standard curve using a known standard

4.5.3 Describe one use of a blank in obtaining spectrophotometric measurements

4.5.4 Determine the concentration of an unknown sample from the standard curve

4.5.5 Identify wavelength and frequency ranges of ultraviolet (UV), visible, and infrared (IR) regions

4.5.6 Show the relationship between concentration of an absorbing species and the transmittance or absorbance of energy

BIL: Essential

EDU:	12	AD	AC
	I	I/P	

Competency 4.6: **Demonstrate proficiency in use of thin-layer chromatography (TLC) and high-performance liquid chromatography (HPLC)**

Key Indicators:

4.6.1 Write a description of the principles of thin-layer chromatography (TLC) as a separation tool

4.6.2 Describe uses of TLC as an analytical tool
4.6.3 Describe components of the apparatus used to conduct TLC
4.6.4 Identify effects of temperature, solvents, and plate types on conducting TLC separations
4.6.5 Perform a TLC separation of a given mixture of substances, including preparing and conditioning the plates, spotting the samples, scanning the plates, and analyzing the data
4.6.6 Identify components in an unknown material using TLC

BIL: Essential

EDU:	12	AD	AC
	I	I/P	

Competency 4.7: Apply basic concepts of spectroscopic analytical methods

Competency Builders:
4.7.1 Draw a diagram of the electromagnetic spectrum indicating wavelength regions from gamma rays to radio waves
4.7.2 Define "spectroscopy" in terms of the interaction of radiant energy and matter
4.7.3 Show the relationship between concentration of an absorbing species and the transmittance or absorbance of energy
4.7.4 Use Beers's Law

BIL: Essential

EDU:	12	AD	AC
		P	

Competency 4.8: **Apply principles of and typical instrumentation in high-performance liquid chromatography (HPLC)**

Key Indicators:

4.8.1 Write a description of the principles of high-performance liquid chromatography (HPLC) as a separation technique

4.8.2 Describe the principles of HPLC that apply to its use as an analytical tool

4.8.3 Identify components of a high-performance liquid chromatography

4.8.4 Identify various column phases (normal, reverse, etc.) and describe the appropriate use of each

4.8.5 Identify various detectors (e.g., diode array, ultraviolet [UV], mass spectrometry [MS] used in HPLC instruments and choose the most appropriate for a variety of situations

4.8.6 Identify parameters of a high-performance liquid chromatograph that influence the chromatogram

4.8.7 Install columns into HPLC instruments

4.8.8 Calibrate one or more HPLC instruments

4.8.9 Use HPLC to separate a known mixture; install columns, choose solvents, choose detectors, and perform calibrations; calculate the percentage of components in mixture

4.8.10 Maximize the performance of an HPLC instrument by adjusting parameters to optimize peak width and resolution and minimize tailing

4.8.11 Operate a computer-controlled HPLC instrument

4.8.12 Perform separations of unknown mixtures using HPLC

4.8.13 Troubleshoot common HPLC problems

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 4.9: Calibrate equipment properly and accurately

Key Indicators:

4.9.1 Describe the use of calibration techniques when performing instrumental analysis
4.9.2 Perform calibrations using available instruments
4.9.3 Plot appropriate graphs
4.9.4 Identify the linear portion of a calibration curve
4.9.5 Describe the causes of nonlinearity in calibration

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 4.10: Maintain laboratory instrumentation

Key Indicators:

4.10.1 Use instrument manuals and follow manual directions appropriately
4.10.2 Identify warnings and cautions
4.10.3 Identify warnings and cautions
4.10.4 Maintain equipment log for instruments in laboratory
4.10.5 Track periodic maintenance schedules
4.10.6 Perform periodic calibration checks on instruments
4.10.7 Ensure that service contracts for key instruments are current

Unit 5: Chemical Materials Handling and Sampling

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 5.1: Describe principles and characteristics of chemical materials

Competency Builders:

5.1.1 Define "chemistry"
5.1.2 Define examples of elements, compounds, and mixtures
5.1.3 Differentiate elements, compounds, and mixtures
5.1.4 Give examples of elements, compounds, and mixtures
5.1.5 Define "atoms" and "molecules"
5.1.6 Draw simple atomic structures for several elements including protons, neutrons, and electrons
5.1.7 Explain electronic configuration
5.1.8 Write simple electronic configurations for several elements
5.1.9 Explain how to use periodic table
5.1.10 Use the periodic table to identify elements and to describe atomic structure
5.1.11 Use the periodic table to characterize elements based on the group
5.1.12 Demonstrate how atoms combine to form molecules
5.1.13 Calculate formula weight
5.1.14 Write balanced chemical reactions
5.1.15 Balance chemical reactions
5.1.16 Demonstrate how compounds react with other compounds to form new compounds as well as relating this to chemical reactions with several examples
5.1.17 Describe the concept of stoichiometry as applied to chemical reactions
5.1.18 Describe chemical bonding and bond types including ionic and covalent
5.1.19 Write the molecular structure of several organic and inorganic compounds using common bond designations
5.1.20 Describe chemical bonding and the relationship of chemical bonding to the physical state of material based on intermolecular bonding; include the concept of hydrogen bonding

5.1.21 Differentiate between organic and inorganic substances
5.1.22 Describe characteristics of organic and inorganic substances
5.1.23 Define "catalyst"
5.1.24 Give examples of materials used as catalysts
5.1.25 Give examples of chemical reactions important to local industries that involve catalysts
5.1.26 Predict endo/exothermic characteristics of a chemical reaction
5.1.27 Calculate heat of reaction for several common reactions

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 5.2: **Use both common and chemical nomenclature for inorganic and organic materials**

Competency Builders:
5.2.1 Use the periodic table to identify and name the elements, according to symbol and group
5.2.2 Name common anions and cations and their charges
5.2.3 Write names and formulas for common inorganic compounds
5.2.4 Write names and chemical structures of common hydrocarbons (aliphatic and aromatic, saturated and unsaturated)
5.2.5 Name organic compounds according to functional groups including ketones, aldehydes, alcohols, ethers, carboxylic acids, esters, amines
5.2.6 Use naming systems, including common and international union of pure and applied chemistry (IUPAC) conventions
5.2.7 Apply various coding systems used for describing the properties of compounds that may be important in hazardous conditions (i.e., Diamond)

Unit 6: Physical Properties Measurement

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 6.1: Apply basic concepts of measurement

Competency Builders:

6.1.1 Describe the importance of measurement in chemistry
6.1.2 Define "precision" and "accuracy"; provide examples of each
6.1.3 Calculate mean, median, mode, and standard deviation for several data sets
6.1.4 Define "confidence limit" in terms of standard deviation
6.1.5 Describe what is meant by significant figures; give examples
6.1.6 Calibrate analytical balances
6.1.7 Use analytical balances for weighing quantities ranging from 0.001 grams to 100 grams to a specified accuracy and precision
6.1.8 Identify, select, and demonstrate proper use of volumetric glassware (burets, graduated cylinders, flasks, and pipets)
6.1.9 Calibrate volumetric glassware
6.1.10 Make quantitative transfers using volumetric glassware
6.1.11 Calculate errors in various measurements based on data acquired using common laboratory equipment
6.1.12 Apply standard rules for determining the number of significant figures in measurements and in the answers to corresponding calculations
6.1.13 Convert units of measure from English to metric and vice versa

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 6.2: **Characterize physical properties of gases, liquids, and solids**

Key Indicators:

6.2.1 Describe gases, liquids, and solids in terms of their physical properties

6.2.2 Show the relationship to changes in temperature and pressure

6.2.3 Describe how physical properties of materials are related to product specifications

6.2.4 Demonstrate use of appropriate apparatus for making the measurement

6.2.5 Assess the accuracy and precision of analytical equipment used in the measurement of several physical properties

6.2.6 Calculate volume, temperature, and pressure for gases, using the ideal gas law, Charles's law and Boyle's law

6.2.7 Describe the effect of changes in temperature and pressure on the physical properties

Unit 7: Biohazard Storage, Handling, and Disposal

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 7.1: Handle infectious agents safely

Key Indicators:

7.1.1 Explain prevention of exposure to infectious agents
7.1.2 Describe basic strategies in safe handling of agents
7.1.3 Explain importance of labeling
7.1.4 Follow Standard Operating Procedures (SOP)
7.1.5 Describe requirements for packaging, shipping and handling of biological specimens
7.1.6 Describe safe package inspection protocol and emergency plans
7.1.7 Explain prevention of aerosol and droplet generation
7.1.8 Demonstrate and analyze production of aerosol
7.1.9 Explain design and use of containment equipment in labs
7.1.10 Define high-efficiency particulate air (HEPA) filter, biological safety cabinet
7.1.11 List personal protection attire
7.1.12 Differentiate primary and secondary barriers
7.1.13 Discuss laboratory biosafety level criteria
7.1.14 List basic characteristics of each of four biosafety levels for infectious agents
7.1.15 Identify potential sources of infectious agents

BIL: Essential

EDU:	12	AD	AC
	I - R	P	

Competency 7.2: Explain safe disposal of infectious waste

Key Indicators:

7.2.1 Explain infectious potential of laboratory waste
7.2.2 Explain occupational and public health risks of infectious lab waste
7.2.3 Demonstrate responsibility for safe handling and disposal
7.2.4 Explain waste handling methods
7.2.5 Describe containment and personal protection
7.2.6 Explain sterilization and containment methods
7.2.7 Describe decontamination, autoclaving, and incineration
7.2.8 Demonstrate effectiveness of various decontamination methods
7.2.9 Sterilize test strip using autoclave

BIL: Essential

EDU:	12	AD	AC
		I	

Competency 7.3: Describe methods used to measure and detect radiation

Competency Builders:

7.3.1 Describe survey meters used for radiation detection
7.3.2 Describe Liquid Scintillation Counting (LSC)
7.3.3 Explain radiation dosimeters and their proper usage
7.3.4 Explain exposure limits
7.3.5 Explain good housekeeping practices to keep radionucleotides outside body
7.3.6 Describe methods for radioisotopes disposal

7.3.7 Explain emergency procedures and decontamination
7.3.8 Explain uses of radioisotopes in biotechnology
7.3.9 Describe use of radioactivity in medicine and consumer products
7.3.10 Explain NRC guidelines for radiation exposure

Unit 8: Basic Microbiology

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 8.1: Apply microbiological principles and procedures

Key Indicators:

8.1.1 Define microbiology
8.1.2 Explain microbial taxonomy and classification
8.1.3 Explain bacterial metabolism, reproduction, cell structures, and their functions
8.1.4 Disinfect and sterilize
8.1.5 Explain classification, composition, and preparation of culture media
8.1.6 Collect, handle and culture specimen
8.1.7 Identify bacteriologic culture techniques necessary for isolation and identification of organisms
8.1.8 Test for antibiotic susceptibility
8.1.9 Identify commonly encountered aerobic bacteria through morphological, physical, and biochemical properties
8.1.10 Prepare Gram stains
8.1.11 Explain collection and handling of specimens for fungal, mycobacterial, and viral specimens
8.1.12 Prepare and examine specimens
8.1.13 Identify difference between autotropic and heterotropic microbes

BIL: Essential

EDU:	12	AD	AC
		I	

Competency 8.2: Explain immunological procedures

Key Indicators:

8.2.1 Explain immune system and normal immune response
8.2.2 Explain physical and chemical properties of immunoglobulins and complement and their reaction in vitro
8.2.3 Explain principles of basic agglutination, flocculation, and precipitation procedures
8.2.4 Perform basic agglutination, flocculation, and precipitation procedures
8.2.5 Explain principles of complement fixation, immunoelectrophoresis and enzyme immunoassay
8.2.6 Explain clinical significance of commonly performed serological tests

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 8.3: Perform common microbiology procedures

Key Indicators:

8.3.1 Operate microscope, compound microscope, incubator, colony counter, and other basic microbiology and analytical equipment
8.3.2 Identify microorganisms and cells
8.3.3 Quantify microorganisms and cells
8.3.4 Isolate pure cultures
8.3.5 Maintain pure cultures
8.3.6 Analyze fermentation materials
8.3.7 Harvest cells

8.3.8 Transform hosts
8.3.9 Stain cells and/or bacteria
8.3.10 Prepare media
8.3.11 Identify sterile techniques used during handling, sampling, and analytical procedures
8.3.12 Explain Koch's Postulates and their use in determining primary and secondary pathogens
8.3.13 Aseptically transfer microorganisms
8.3.14 Sterilize all materials and equipment to be used in fermentation process

BIL: Essential

EDU:	12	AD	AC
	I/P	P	

Competency 8.4: Contrast prokaryotic and eukaryotic cells

Key Indicators:
8.4.1 Define prokaryotic and eukaryotic
8.4.2 List parts of prokaryotic and eukaryotic cells
8.4.3 State function of each cell structure
8.4.4 Distinguish between those parts that are common to both and those that are not always present
8.4.5 Describe the cell wall/cell membrane
8.4.6 Explain endospore
8.4.7 Identify conditions that favor the formation of endospores
8.4.8 Explain plasmid
8.4.9 Identify groups of microorganisms such as bacteria, algae, fungi, etc.

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 8.5: Explain microbial growth

Key Indicators:

8.5.1 Correlate bacterial binary fission with generation time
8.5.2 Describe normal bacteria population growth curve
8.5.3 Indicate methods of enumerating bacteria and measuring bacterial growth
8.5.4 Explain closed bacterial culture
8.5.5 Describe physical factors that affect microbial growth

Unit 9: Biochemical Technology

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.1: **Prepare common laboratory reagents**

Key Indicators:

9.1.1 Define mole, molarity, normality, percent w/v and percent v/v
9.1.2 Perform serial dilution
9.1.3 Describe and prepare buffers
9.1.4 List useful buffers for biological systems
9.1.5 Adjust the pH of stock reagents
9.1.6 Describe ionic and non-ionic detergents
9.1.7 Dilute stock solutions to working solutions
9.1.8 Prepare sterile solutions

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.2: **Demonstrate basic, one-step chemical laboratory skills**

Key Indicators:

9.2.1 Identify appropriate glassware for task
9.2.2 Stored prepared solutions and stains to maintain optimal condition
9.2.3 Operate laboratory instruments
9.2.4 Measure using MKS system (metric)

9.2.5 Identify storage containers that are compatible with the materials to be stored
9.2.6 Use safety hoods
9.2.7 Utilize solvents, acids, and detergents for cleaning
9.2.8 Prepare solutions
9.2.9 Demonstrate the proper use of pressurized cylinders
9.2.10 Measure volume of a solution to perform a laboratory test
9.2.11 Measure temperatures accurately
9.2.12 Wash laboratory equipment appropriately
9.2.13 Sterilize equipment to decontaminate soiled materials

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.3: Demonstrate combinations of chemical laboratory skills

Key Indicators:

9.3.1 Describe typical laboratory procedures (e.g., heating, cooling, filtration, glassware, setup, distillation, weighing, measuring, pipetting, volumetrics)
9.3.2 Carry out laboratory procedures from a written procedure
9.3.3 Respond to a laboratory spill
9.3.4 Practice safe and proper use of hand tools
9.3.5 Use proper techniques for mixing acids and bases with other materials
9.3.6 Demonstrate proper titration techniques
9.3.7 Describe the physical and chemical properties of common materials and implications for storage
9.3.8 Transfer liquids, solids, and gases properly
9.3.9 Maintain electrodes
9.3.10 Use all common types of volumetric equipment and apparatus

BIL: Essential

EDU:	12	AD	AC
	I	R/P	

Competency 9.4: **Identify/describe the following chemical lab equipment and instruments**

Key Indicators:

9.4.1 Use titrator
9.4.2 Use Geiger Mueller counter
9.4.3 Use alpha/beta counter
9.4.4 Use oil immersion lens
9.4.5 Use Bunsen/Fisher burner safely
9.4.6 Use autoclaves, hot air oven, and disinfectants

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.5: **Perform critical laboratory calculations and measurements**

Key Indicators:

9.5.1 Calculate quantities needed to perform a test analysis
9.5.2 Calculate unit conversions
9.5.3 Calculate concentrations
9.5.4 Construct graphs

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.6: Perform sample analysis

Key Indicators:

9.6.1 Obtain representative samples
9.6.2 Make observations regarding condition of sample and record any notable characteristics
9.6.3 Identify the appropriate equipment for the analysis to be conducted
9.6.4 Gather and clean the necessary glassware, reagents, and chemicals
9.6.5 Calibrate equipment
9.6.6 Prepare and standardize reagents
9.6.7 Prepare samples for analysis (e.g., dissolve, digest, combust, ash)
9.6.8 Prepare standards and control samples
9.6.9 Analyze sample
9.6.10 Calculate results to appropriate significant figures
9.6.11 Evaluate analytical results and respond appropriately
9.6.12 Identify conditions that indicate need for an analysis to be repeated
9.6.13 Record and report data
9.6.14 Return all equipment and material to original storage locations

BIL: Essential

EDU:	12	AD	AC
	I	R/P	

Competency 9.7: **Describe molecular behavior of amino acids and peptides**

Key Indicators:

9.7.1 Draw a structure of an amino acid
9.7.2 Build model of an amino acid
9.7.3 Identify chemical properties of peptide bond
9.7.4 Identify four factors that determine isoelectric point of an amino acid and a protein
9.7.5 Determine polarity of functional groups on individual amino acids
9.7.6 Explain the solubility of an amino acid and a protein in terms of isoelectric point
9.7.7 Determine the isoelectric point of amino acids and proteins
9.7.8 Predict the effect of the isoelectric point on molecular behavior of amino acid and protein

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.8: **Explain protein properties**

Key Indicators:

9.8.1 Differentiate levels of protein structure
9.8.2 Describe characteristics of each level
9.8.3 Describe methods of denaturing proteins
9.8.4 Describe ways proteins can be renatured

9.8.5 Identify four methods of renaturation
9.8.6 Explain properties that allow for molecular renaturation

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.9: Perform enzyme assays

Key Indicators:
9.9.1 Generalize factors affecting rates of reaction
9.9.2 Explain factors optimizing rates of reaction
9.9.3 Distinguish substrate and product from catalyst in function and role
9.9.4 Explain parameters of reaction
9.9.5 Assemble correct supplies needed for assay
9.9.6 Determine kinetics of an enzyme catalyzed reaction
9.9.7 Distinguish various methods to graph data
9.9.8 Perform enzyme-linked immunosorbent assay (ELISA)

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.10: Perform biochemical assays of nucleotides and nucleic acids

Key Indicators:
9.10.1 Identify three components of a nucleotide
9.10.2 Differentiate nucleotides and nucleosides
9.10.3 Isolate nucleic acids

9.10.4 Perform UV spectra of proteins and nucleic acids
9.10.5 Explain limitation of techniques

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.11: Explain the relationship between deoxyribonucleic acid (DNA), ribonucleic acid (RNA), and protein

Key Indicators:
9.11.1 Explain how DNA is the genetic material
9.11.2 Discuss transcription of genes
9.11.3 Explain translation of a messenger RNA into protein
9.11.4 Identify the key elements of the transcription and translational machinery

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.12: Describe deoxyribonuckeic acid (DNA) replication

Key Indicators:
9.12.1 Outline DNA replication cycle
9.12.2 Identify conditions under which replication occurs
9.12.3 Differentiate the replication cycles of procaryotes and eukaryotes
9.12.4 Identify mutagenic and repair mechanisms of DNA
9.12.5 Identify mutagenic processes and repair mechanisms
9.12.6 Explain how mutagenic mechanisms modify organisms

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.13: Describe biochemical assays of carbohydrates

Key Indicators:
9.13.1 Identify components of monosaccharides
9.13.2 Draw structural formula for a disaccharide
9.13.3 Distinguish uses and limitations of various assays

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 9.14: Describe biochemicals assays of lipids

Key Indicators:
9.14.1 Compare and contrast major classes of lipids
9.14.2 Identify functional groups and chemical reactivity of classes
9.14.3 Identify basis of chemical reactions of assay

BIL: Essential

EDU:	12	AD	AC
	I	R	

Competency 9.15: Describe membrane fractionation

Key Indicators:

9.15.1 Diagram cell membrane
9.15.2 Outline function of molecules within membrane structure
9.15.3 Relate diagram to explanation of fluid mosaic model
9.15.4 Identify membrane purification/separation techniques

Unit 10: Molecular Biology Technology

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 10.1: Explain genetics and heredity

Key Indicators:

10.1.1 Define and discuss Mendel's work and research
10.1.2 Describe basic genetic crosses
10.1.3 Describe meiosis and genetic recombination
10.1.4 Diagram linkage mapping and solve linkage problems
10.1.5 Determine whether a trait is dominant or recessive
10.1.6 Determine whether a trait is sex-linked or autosomal
10.1.7 Analyze and solve sex-linkage problems
10.1.8 Apply Mendelian patterns to family trees with medical problems

BIL: Recommend

EDU:	12	AD	AC
	I	R/P	

Competency 10.2: Describe historical developments leading to modern recombinant deoxyribonucleic acid (DNA) technology

Key Indicators:

10.2.1 Describe work of early and recent scientists
10.2.2 Trace developments and discoveries in genetics
10.2.3 Outline and highlight major events in deoxyribonucleic acid (DNA) technology history

10.2.4 Analyze trends, controversies, breakthroughs
10.2.5 Explain in writing how early scientists' work led to gene cloning techniques

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 10.3: Apply basic concept of recombinant deoxyribonucleic acid (DNA) technology

Key Indicators:
10.3.1 Diagram the relationships among deoxyribonucleic acid (DNA), ribonucleic acid (RNA), and protein
10.3.2 Define basic components of cloning
10.3.3 Identify specific terms: vectors, restriction enzymes, host transformation, and electrophoresis
10.3.4 Apply these concepts to simulated applications
10.3.5 Identify unique restriction enzyme sites
10.3.6 Purify DNA
10.3.7 Purify RNA

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 10.4: Isolate and characterize deoxyribonucleic acid (DNA)

Competency Builders:

10.4.1 Explain large scale double-stranded deoxyribonucleic acid (DNA) isolation methods
10.4.2 Explain mini-prep double-stranded DNA isolation of plasmid DNA
10.4.3 Explain genomic DNA isolation from blood samples according to Federal Bureau of Investigation (FBI) protocol
10.4.4 Perform restriction digest
10.4.5 Perform electrophoresis
10.4.6 Prepare graph and assess results
10.4.7 Determine molecular weight of fragments correctly

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 10.5: Clone deoxyribonucleic acid (DNA)

Key Indicators:

10.5.1 Clone a gene for antibiotic resistance into a vector
10.5.2 Ensure transformed E. coli acquire antibiotic resistance
10.5.3 Prepare a report on cloning exercise
10.5.4 Describe terminology and processes in deoxyribonucleic acid (DNA) technology
10.5.5 Prepare reagents and materials

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 10.6: **Perform advanced techniques in recombinant deoxyribonucleic acid (DNA) technology**

Key Indicators:

10.6.1 Perform Southern Blot or colony transfer
10.6.2 Perform Probe Preparation
10.6.3 Perform Hybridization
10.6.4 Identify and organize protocols
10.6.5 Prepare flowchart of overall procedure
10.6.6 Follow tasks in each protocol
10.6.7 Summarize in writing procedures and results
10.6.8 Explain techniques
10.6.9 Apply concepts of screening, genetic expression, expression vectors, and genetic libraries
10.6.10 Perform polymerase chain reaction (PCR) technique

BIL: Recommend

EDU:	12	AD	AC
	I	R/P	

Competency 10.7: **Relate molecular biology technology to our lives**

Key Indicators:

10.7.1 Explain results from the Human Genome project and other sequencing projects
10.7.2 Explain human genome map data
10.7.3 Explain how gene sequencing is performed
10.7.4 Give sequencing examples of medical or agricultural advances

10.7.5 Give examples of how this information is used in today's applications
10.7.6 Relate molecular biology to recent advances in local medicine, food science, or agriculture industries
10.7.7 Explain field applications of genetherapy, forensics, and animal husbandry

Unit 11: Cell Culturing

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 11.1: Describe the history of cell culture

Key Indicators:
11.1.1 Identify major historic advances in cell culture
11.1.2 Describe advantages and disadvantages of cell culture
11.1.3 Define different types of cultures

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 11.2: Describe equipment needs of a tissue culture lab

Key Indicators:
11.2.1 Describe essential and beneficial equipment for tissue culture facility
11.2.2 Describe other types of equipment found in tissue culture facilities
11.2.3 Describe necessary consumable items used in tissue culture facilities

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 11.3: ***Describe aseptic technique***

Competency Builders:

11.3.1 Describe objectives of aseptic technique
11.3.2 Describe good technique for work surface, personal hygiene, pipetting and sterile handling
11.3.3 Explain mechanism for laminar flow hoods

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 11.4: **Explain factors that influence cell growth during incubation**

Key Indicators:

11.4.1 Compare surfaces and dishes, plates, and vessels that cells will grow on
11.4.2 Explain relationship between carbon dioxide, temperature, buffering, and pH
11.4.3 Describe basic constituents of media
11.4.4 Contrast advantages and disadvantages of serum-free media

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 11.5: Prepare media for culturing cells

Key Indicators:

11.5.1 Clean and sterilize equipment
11.5.2 Prepare media and sterilize by filtration
11.5.3 Test media for sterility
11.5.4 Describe components needed for media
11.5.5 Explain function of each media component
11.5.6 List hormones to stimulate growth
11.5.7 Use serum-free media

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 11.6: Maintain and passage aseptically cultured cells

Key Indicators:

11.6.1 Culture common cell lines without contamination
11.6.2 Establish primary cell culture
11.6.3 Count cells using a hemocytometer
11.6.4 Demonstrate cryopreservation techniques by freezing and thawing cells

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 11.7: Explain methods for analysis of cultured cells

Key Indicators:

11.7.1 Describe methods for deoxyribonucleic acid (DNA), ribonucleic acid (RNA), and protein analysis of harvested cells
11.7.2 Explain how cell cultures can be used to assay viability and cytotoxicity
11.7.3 Transfect cells with plasmid deoxyribonucleic acid (DNA)
11.7.4 Select transfected cells
11.7.5 Clone transfected cells
11.7.6 Describe the fusion process to create hybridoma cells
11.7.7 Describe the use of enzyme-linked immunosorbent assay (ELISA) to screen hybridoma cells for antibody production

BIL: Essential

EDU:	12	AD	AC
	R	P	

Competency 11.8: Describe basic antibody-mediated immunity

Key Indicators:

11.8.1 Describe the basic biology of B cells and T cells
11.8.2 Diagram an antibody molecule
11.8.3 Define and compare polyclonal and monoclonal antibodies
11.8.4 Describe methods and uses for antibodies, enzyme-linked immunosorbent assay (ELISA), Western Blot, and hybridoma production

BIL: Essential

EDU:	12	AD	AC
	I	R	

Competency 11.9: Describe the use of animals in research

Competency Builders:

11.9.1 Describe ethical considerations of animal use
11.9.2 Describe regulations regarding animal care and use
11.9.3 Apply knowledge of federal, state, and local animal welfare regulations
11.9.4 Describe proper injection technique for immunization of mice

Unit 12: Protein Bioseparation Methods

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 12.1: Explain basic chromatographic theory

Key Indicators:

12.1.1 Define the relationship between chromatography and biphasic separation
12.1.2 Classify chromatographic methods by type
12.1.3 Select appropriate chromatographic method for circumstance/situation
12.1.4 Show diagrammatically a stationary and mobile phase, column and fraction

BIL: Recommend

EDU:	12	AD	AC
	I	P	

Competency 12.2: Interpret chromatographic results

Key Indicators:

12.2.1 Perform qualitative and quantitative analysis to determine amount and type of unknown sample
12.2.2 Detect uncertainties in analysis
12.2.3 Point out ways to confirm analysis

BIL: Recommend

EDU:	12	AD	AC
		P	

Competency 12.3: **Prepare and run various types of chromatography separation**

Key Indicators:

12.3.1 Pour, pack, and run gel permeation chromatography column
12.3.2 Successfully separate test mixture into its components
12.3.3 Collect fractions
12.3.4 Evaluate fractions using spectrophotometer and an electrophoresis

BIL: Recommend

EDU:	12	AD	AC
		P	

Competency 12.4: **Interpret results of various types of chromatography separation**

Key Indicators:

12.4.1 Explain results in terms of molecular weight of sample components
12.4.2 Identify unknown correctly
12.4.3 Evaluate chromatograms using measurement skills
12.4.4 Summarize procedures
12.4.5 Document results
12.4.6 Prepare formal report that summarizes interpretation of results in tabular and text form

BIL: Essential

EDU:	12	AD	AC
		I	

Competency 12.5: **Perform proper maintenance and operation techniques to high-performance liquid chromatography (HPLC) system**

Key Indicators:

12.5.1 Attach proper column to system
12.5.2 Check for leaks
12.5.3 Check pressure
12.5.4 Prime pump and run test sample
12.5.5 Store column in correct storage solution
12.5.6 Identify components of high-performance liquid chromatography (HPLC) system and trace flow of liquid

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 12.6: **Run sample on high-performance liquid chromatography (HPLC) system and interpret results**

Key Indicators:

12.6.1 Obtain correct separation of sample components
12.6.2 Explain results in terms of reverse phase column and sample interactions
12.6.3 Identify unknown correctly
12.6.4 Evaluate chromatograms using measurement skills
12.6.5 Summarize procedures

12.6.6 Document results
12.6.7 Prepare formal report that includes interpretation of results in tabular and text form

BIL: Recommend

EDU:	12	AD	AC
	I	P	

Competency 12.7: **Identify and explain physical and chemical properties of proteins**

Key Indicators:
12.7.1 Relate physical properties of a protein to separation methods
12.7.2 Relate chemical properties of a protein to separation methods
12.7.3 Design a separation strategy based on this information

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 12.8: **Desalt protein and change buffer**

Key Indicators:
12.8.1 Describe how to desalt a sample and change buffer
12.8.2 Identify all steps in desalting process
12.8.3 Perform dialysis
12.8.4 Dialysate with pH of proper buffer, proper conductivity, and activity

BIL: Recommend

EDU:	12	AD	AC
		I/R	

Competency 12.9: Perform ion exchange chromatography

Key Indicators:

12.9.1 Explain principles of chromatographic separation
12.9.2 Explain and distinguish between cationic and anionic exchangers
12.9.3 Set up chromatography column with DEAE
12.9.4 Inspect for correct orientation and no bubbles in connecting tube
12.9.5 Run sample on chromatography column
12.9.6 Collect fractions
12.9.7 Graph data from column fractions
12.9.8 Use assays from extraction in supernatant
12.9.9 Produce concentrated samples
12.9.10 Document and explain procedure

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 12.10: Perform electrophoresis of protein samples

Key Indicators:

12.10.1 Write an explanation of theory of SDS polyacrylamide gel electrophoresis SDS (PAGE) and isoelectric focusing (IEF)
12.10.2 Cast a PAGE gel
12.10.3 Run samples on PAGE
12.10.4 Perform Western Blot
12.10.5 Cast an Isoelectric Focusing (IEF) gel

12.10.6 Transfer IEF gel to Sodium Dodecyl Sulfate (SDS PAGE) gel
12.10.7 Run samples

BIL: Recommend

EDU:	12	AD	AC
	I	P	

Competency 12.11: Perform affinity purification

Key Indicators:
12.11.1 Describe immuno-affinity chromatography techniques
12.11.2 Demonstrate protein A/G purification of antibodies
12.11.3 Describe hydrophobic chromatography methods
12.11.4 Describe ligand-receptor for enzyme purification

Unit 13: Fermentation Technology

BIL: Recommend

EDU:	12	AD	AC
	I	P	

Competency 13.1: **Explain various fermentation and bioprocessing applications and the effects of fermentation operations on cell growth kinetics**

Key Indicators:

13.1.1 Explain various product types and classes of fermentation or bioprocessing
13.1.2 Describe advantages and disadvantages of various fermentation processes
13.1.3 Outline function of parts of bench-top fermenter
13.1.4 Describe function of parts of bench-top fermenter
13.1.5 Write material balance for substrates and products
13.1.6 Identify factors determining efficiency of process
13.1.7 Apply appropriate mathematical functions to calculations
13.1.3 Describe relationship of oxygen transfer rates to mass transfer
13.1.4 Monitor microorganism growth in appropriate media
13.1.5 Determine viability of stored cells

BIL: Essential

EDU:	12	AD	AC
		I	

Competency 13.2: Validate principles and importance of sterility in industrial fermentations

Key Indicators:

13.2.1 Explain important features of aseptic technique in terms of absolute sterility

13.2.2 Write explanation of sterlity

13.2.2 Explain the temperature/pressure relationship of saturated steam to sterilization

13.2.3 Explain the effect of entrapped air on sterilization effectiveness

13.2.4 Compare sterilization methods using dry heat versus moist heat

13.2.5 Demonstrate sterilization by micro-filtration

13.2.6 Explain the effect of suspended solids in fermentation media on sterilization effectiveness

13.2.7 Prepare an uncontaminated sample for analysis

Unit 14: Microbiology for Biotechnology

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 14.1: **Describe the general structure of viruses**

Key Indicators:

14.1.1 Describe various coverings, central core structures
14.1.2 Describe viral capsid
14.1.3 Distinguish between helical and icosahedral viruses
14.1.4 Explain origin of viral envelope

BIL: Recommend

EDU:	12	AD	AC
		I	

Competency 14.2: **Explain how chemical energy operates major cell processes (i.e., biosynthesis, movement, transport, and growth)**

Key Indicators:

14.2.1 Describe biological oxidation and reduction
14.2.2 Describe structure of ATP
14.2.3 Illustrate general processes of endergonic and exergonic reactions
14.2.4 Explain concept of reduction and osidation (REDOX)
14.2.5 Relate ATP synthesis to catabolism and anabolism

BIL: Recommend

EDU:	12	AD	AC
	I/R	P	

Competency 14.3: Describe active and passive transport

Key Indicators:

14.3.1 Identify three types of passive transport
14.3.2 Identify features in active transport systems
14.3.3 Describe two forms of endocytosis

Unit 15: Bioethics

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 15.1: Identify basic principles of ethics

Key Indicators:

15.1.1 Define bioethics
15.1.2 Identify importance of replication of experiments
15.1.3 Identify ethical uses of animals in research (purpose, safety mechanisms, avoidance of unnecessary duplication)
15.1.4 Identify ethical and unethical behavior in lab setting
15.1.5 Identify ethical and unethical behavior in personal life
15.1.6 Explain methods for protecting the integrity of data
15.1.7 Explain importance of protecting the integrity of data

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 15.2: Apply principles of ethics to scientific problems

Key Indicators:

15.2.1 Identify rules for discussion of ethical issues in a public forum
15.2.2 Apply science ethically to a variety of situations
15.2.3 Identify ethical issues specific to a particular company or position

Unit 16: Water and Wastewater Treatment Operations

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 16.1: **Identify characteristics and principles of water and wastewater treatment**

Key Indicators:

16.1.1 Describe the hydrologic cycle
16.1.2 Identify constituents inherent to groundwater and/or surface water
16.1.3 Describe the pH scale and its importance in the water-treatment process
16.1.4 Correlate treatment processes to types of facility influent and solids
16.1.5 Identify biological organisms used in treatment processes
16.1.6 Identify commonly measured wastewater items
16.1.7 Identify factors affecting raw wastewater
16.1.8 Identify water and wastewater borne diseases
16.1.9 Identify gases found in wastewater
16.1.10 Define pathogenic organisms, include bacteria, protozoa, and virus
16.1.11 Describe the disease associations of pathogenic organisms

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 16.2: **Identify wastewater sampling techniques**

Key Indicators:

16.2.1 Identify reasons for sampling and the types of samples (e.g., simple, representative, grab, composite)
16.2.2 Describe methods of sample collection and handling

16.2.3 Identify biological or chemical specific samples required for process control and compliance with standards
16.2.4 Identify representative sampling points
16.2.5 Identify the basic procedure for quality control/quality assurance in sampling
16.2.6 Describe the correct procedure for obtaining a bacteriological sample
16.2.7 Describe the correct procedure for sample identification
16.2.8 Define the chain of custody for a sample
16.2.9 Describe correct sample-collection procedures for inorganic and organic analyses
16.2.10 Describe the need for chemical analyses in water treatment
16.2.11 Determine whether the finished water is acceptable or unacceptable, according to laboratory results

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 16.3: Describe wastewater collection systems

Key Indicators:
16.3.1 Identify types of wastewater collection systems
16.3.2 Identify flow variations and conditions that affect plant treatment including infiltration, inflow, and lift stations
16.3.3 Describe methods to detect and correct infiltration and inflow
16.3.4 Identify dissolved gases in wastewater and the effect of their presence/absence on treatment
16.3.5 Explain the effect of lift station performance on the overall treatment process
16.3.6 Describe solutions for lift station problems such as surging flows, septic conditions, and power outages

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 16.4: **Identify constituents of water entering water-treatment facility**

Key Indicators:

16.4.1 Differentiate between turbidity and the microbiological quality of water
16.4.2 Describe the uses of chemical analysis in water-treatment operations
16.4.3 Identify symbols and common names for elements and chemical compounds
16.4.4 Identify the primary constituents to be measured
16.4.5 Explain the importance of water treatment for the control of coliform bacteria and algae

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 16.5: **Analyze the constituents of wastewater**

Key Indicators:

16.5.1 Describe the need for chemical analysis in waste water treatment
16.5.2 Identify laboratory tests required by the NPDES Permit
16.5.3 Analyze the specific physical, chemical, and biological characteristics of wastewater
16.5.4 Analyze attached and suspended growth, respiration, gas production, aerobic and anaerobic conditions, differences in effluent disposal, and solids management
16.5.5 Identify ranges in wastewater treatment and limits on facility discharges

16.5.6 Determine the significance of biological or chemical sample results for process control and reporting
16.5.7 Describe the laboratory test performed for the presence of bacteria
16.5.8 Determine whether the finished water is acceptable or unacceptable, according to laboratory results

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 16.6: Contrast the aeration and stripping process

Key Indicators:
16.6.1 Identify types of aeration systems
16.6.2 Explain the benefits of aeration
16.6.3 Describe the components of an air-stripping system
16.6.4 Describe process control methods for aeration systems

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 16.7: Describe the mixing, coagulation, and flocculation Processes

Key Indicators:
16.7.1 Define turbidity, color, coagulation, and flocculation
16.7.2 Identify the kinds of equipment used in the coagulation process
16.7.3 Identify coagulant chemicals used in water-treatment facilities
16.7.4 Identify the steps of coagulation

16.7.5 Identify specific sampling locations for control in a coagulation process
16.7.6 Identify factors that would contribute to poor flocculation
16.7.7 Compute the feed rate in pounds per day when the chemical coagulant and flowrate are known
16.7.8 Compute the dosage of coagulant when the rate of flow and the feed rate of the chemical coagulant are known

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 16.8: Describe the filtration and sedimentation process

Key Indicators:
16.8.1 Explain concepts related to filtration including types of filters, filter-system components, and the steps for normal filtration operations
16.8.2 Explain common problems of filtering systems including head loss, mudballs, filter media loss, and blinding
16.8.3 Describe when to backwash a filter
16.8.4 Identify the steps for backwashing a filter
16.8.5 Explain filter backwash rates
16.8.6 Explain concepts of sedimentation, including types of classifiers, sedimentation system components and steps for normal operation
16.8.7 Measure sedimentation rates

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 16.9: Describe the water-softening process

Key Indicators:

16.9.1 Identify treatment processes used for water softening
16.9.2 Describe types of hardness
16.9.3 Describe alkalinity and its components
16.9.4 Calculate the distribution of bicarbonate, carbonate, and/or hydroxide ions when given the total alkalinity and phenolphthalein alkalinity
16.9.5 Describe carbonate removal
16.9.6 Identify the important zones of an upflow clarifier unit
16.9.7 Identify the appropriate chemical(s) to use in chemical-precipitation softening process
16.9.8 Compute lime demand from raw-water analyses
16.9.9 Describe the reasons for recarbonization
16.9.10 Compute hardness removal when the ion-exchange capacity is known

BIL: Recommended

EDU:	12	AD	AC
	I	P	

Competency 16.10: Describe the stabilization process

Key Indicators:

16.10.1 Identify the chemicals used in stabilization
16.10.2 Identify two stabilization indices
16.10.3 Determine water stability using the Langelier index and the marble test

BIL: Recommended

EDU:	12	AD	AC
	I	P	

Competency 16.11: Describe the corrosion-control process

Key Indicators:

16.11.1 Describe problems that can be created by corrosive waters
16.11.2 Define electrochemical reaction
16.11.3 Identify the factors that influence corrosion
16.11.4 Define cathode film formation
16.11.5 Describe the conditions for calcium carbonate film formation
16.11.6 Identify the chemicals used in corrosion control
16.11.7 Define cathodic protection and its application in water-treatment

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 16.12: Describe the disinfection process

Key Indicators:

16.12.1 Identify chemicals used in primary disinfection
16.12.2 Identify commonly used chlorinators and hypochlorinators
16.12.3 Determine the maximum amount of chlorine gas (in pounds) that may be taken from a cylinder in a 24-hour period
16.12.4 Identify proper maintenance procedures for equipment cholorination
16.12.5 Identify terminology related to chlorination and disinfection
16.12.6 Identify common safety problems or emergency situations that might occur during chlorination
16.12.7 Identify the properties of chlorine and its use in water treatment

16.12.8 Explain the points at which chlorine is applied most effectively in water treatment

16.12.9 Compute the feed rate needed to treat a given amount of water when given a chlorine demand and the desired chlorine residual

BIL: Recommended

EDU:	12	AD	AC
	I	P	

Competency 16.13: Describe the control and treatment of trihalomethanes

Key Indicators:

16.13.1 Describe the formation of total trihalomethanes (TTHM)

16.13.2 Describe the specific procedure for collecting samples to determine trihalomethane levels

16.13.3 Compute the quarterly average and the annual TTHM measurements when sample results are given

16.13.4 Identify processes that remove trihalomethane precursors

16.13.5 Identify processes that remove trihalomethanes after they are formed

16.13.6 Identify the benefits of alternate disinfectants

16.13.7 Describe chloramination as a control of TTHM

Unit 17: Environmental Science

BIL: Recommended

EDU:	12	AD	AC
	P	R	

Competency 17.1: **Explain the relationships between plants and animals within ecosystems**

Key Indicators:

17.1.1 Classify the major categories of organisms
17.1.2 Differentiate among biomes
17.1.3 Differentiate among types of ecosystems
17.1.4 Identify the functions of producers and consumers
17.1.5 Compare the growth and development of various types of plant forms
17.1.6 Describe the interactions between producers, consumers, and decomposers and antagonists
17.1.7 Illustrate a food chain and food web
17.1.8 Trace the effects of pollution through a food chain
17.1.9 Differentiate between biodegradable and non-biodegradable products
17.1.10 Differentiate between organic farming and farming practices that incorporate the use of biocides and inorganic fertilizers and their Differentiate among the various types of habitat and their importance to natural comparative effects on the environment
17.1.11 systems
17.1.12 Identify several causes for the habit reduction
17.1.13 Explain why preservation of habitat is essential
17.1.14 Cite examples of threatened, endangered, and extinct plant and animal species
17.1.15 Explain the processes governing an organism's ability to respond to and survive environmental changes
17.1.16 List the steps of ecological succession
17.1.17 Give examples of how human activity impact succession
17.1.18 Provide examples of types of adaption
17.1.19 Describe microorganisms used to improve ecology

BIL: Essential

EDU:	12	AD	AC
	P	R	

Competency 17.2: Describe the character and value of natural resources

Key Indicators:

17.2.1 Describe the value of natural resources
17.2.2 Describe the types and distributions of natural resources
17.2.3 Differentiate between renewable and non-renewable natural resources

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 17.3: Evaluate the inappropriate use of natural resources

Key Indicators:

17.3.1 Describe natural events which alter the environment
17.3.2 Describe various methods used to obtain natural resources
17.3.3 Identify the primary factor for the exploitation of natural resources
17.3.4 Identify the technological advances contributing to the exploitation of natural resources by industry, agriculture, and transportation
17.3.5 Cite examples of the results of overuse that occur from exploitation of natural resources
17.3.6 Explain the circumstances contributing to accidental, incidental and deliberate resource abuse

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 17.4: Describe the impact of an increasing human population

Key Indicators:

17.4.1 Define doubling time, natural increase, natural decrease, rate of population change, and zero population growth

17.4.2 Interpret a population profile

17.4.3 Explain the relationship between a country's economic status and its population

17.4.4 Identify the results of increases in the population on the environment

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 17.5: Identify the impact of organizations/individuals on the development of environmental policies and issues

Key Indicators:

17.5.1 Recognize organizations involved with environmental issues

17.5.2 Identify the major issues addressed by environmental organizations

17.5.3 Match major events in restoration and/or conservation activities to the organizations responsible

17.5.4 List methods governmental agencies used to arrive at decisions affecting the environment

17.5.5 Identify recent environmental legislation

17.5.6 Describe advantages industry has over individuals on shaping environmental policy

17.5.7 Evaluate results of environmental restoration and conservation efforts
17.5.8 Explain the role of the public in fostering environmental protection
17.5.9 Explain the role of the public in creating environmental harm
17.5.10 Compare and contrast competing interests between environmentalists and economists

BIL: Essential

EDU:	12	AD	AC
	P	R	

Competency 17.6: Describe the impact and implications of resource conservation and pollution abatement

Key Indicators:
17.6.1 Explain the importance of resource conservation
17.6.2 Cite examples of various levels of resource conservation
17.6.3 Identify the results of conservation efforts
17.6.4 Describe economic issues of conservation efforts
17.6.5 Identify non-economic benefits of conservation activities
17.6.6 Describe pollution prevention principles

BIL: Essential

EDU:	12	AD	AC
	P	R	

Competency 17.7: **Describe the impact and implications of environment preservation**

Key Indicators:

17.7.1 Explain the importance of environmental preservation
17.7.2 Cite examples of environmental preservation
17.7.3 Identify the results of preservation efforts
17.7.4 Describe economic issues of preservation efforts
17.7.5 Identify non-economic benefits of preservation activities

BIL: Essential

EDU:	12	AD	AC
	P	R	

Competency 17.8: **Identify the role of responsible stewardship in maintaining a healthy environment**

Key Indicators:

17.8.1 Define responsible stewardship
17.8.2 Explain the need for responsible stewardship and environmental accountability
17.8.3 Identify types of environmental accountability
17.8.4 Compare results stemming from responsible and irresponsible stewardships

Unit 18: Environmental Assessments

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 18.1: Describe Phase 1 assessment

Key Indicators:

18.1.1 Identify key elements in Phase 1, II, and III assessments
18.1.2 Describe the importance of a title search
18.1.3 Gather drainage area data
18.1.4 Complete field data sheet
18.1.5 Record physical and topographical data
18.1.6 Interpret basic soil differences
18.1.7 Measure ground water level
18.1.8 Identify flood plain areas
18.1.9 Measure stream flow
18.1.10 Complete a title search

BIL: Essential

EDU:	12	AD	AC
		I	

Competency 18.2: Identify past practices

Key Indicators:

18.2.1 Locate regulatory reference materials
18.2.2 Collect background information
18.2.3 Verify accuracy of information
18.2.4 Investigate background of complaint

18.2.5 Interact with various regulatory agencies
18.2.6 Use regulatory reference materials

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 18.3: Conduct lab/field analysis (Phase 2)

Key Indicators:
18.3.1 Perform Biochemical Oxygen Demand analysis
18.3.2 Perform Chemical Oxygen Demand analysis
18.3.3 Perform pH analysis
18.3.4 Perform specific conductivity analysis
18.3.5 Perform dissolved oxygen analysis
18.3.6 Perform suspended solids analysis
18.3.7 Measure water temperature, water hardness, water level and flow
18.3.8 Perform nitrates and nitrites analysis
18.3.9 Measure turbidity
18.3.10 Measure oxygen level
18.3.11 Analyze water using portable test kit
18.3.12 Measure Lower Explosive Levels
18.3.13 Measure air flow rate and temperature
18.3.14 Perform air particulate analysis
18.3.15 Describe procedures for measuring toxic gasses, organic vapors, and radiation
18.3.16 Measure basic field levels of contamination
18.3.17 Perform percolation test
18.3.18 Determine moisture content/dry content
18.3.19 Measure density
18.3.20 Measure chlorinated compounds
18.3.21 Identify background analytical data to establish norm for site

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 18.4: Collect physical data (Phase 2)

Key Indicators:

18.4.1 Identify safety hazards of materials
18.4.2 Develop "Chain of Custody" procedures
18.4.3 Identify physical condition of materials
18.4.4 Identify marking procedures
18.4.5 Select sampling tools
18.4.6 Identify preparation and preservation procedures of samples
18.4.7 Collect and label samples
18.4.8 Document samples using Chain of Custody forms
18.4.9 Sign over Chain of Custody form

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 18.5: Remediate site (Phase 3)

Key Indicators:

18.5.1 Identify options
18.5.2 Resolve issue with concerned party(ies)
18.5.3 Assess options for corrective action
18.5.4 Implement selected option for correction
18.5.5 Document investigation with summary reports

Unit 19: Introduction to Industry

BIL: Essential

EDU:	12	AD	AC
	I	R	

Competency 19.1: Describe the impact of the biotechnology industry

Key Indicators:

19.1.1 Identify industries that use biotechnology

19.1.2 Describe and assess the impact of biotechnology on contemporary society

19.1.3 Differentiate new areas of biotechnology from earlier uses

19.1.4 Identify types of products or processes used by biotechnology companies

19.1.5 Contrast differences between laboratories using biotechnology for research and development versus production facilities

19.1.6 Explain differences between commercial laboratory endeavors as opposed to academic research

BIL: Essential

EDU:	12	AD	AC
	I	R	

Competency 19.2: Classify applications of biotechnology by major industry uses

Key Indicators:

19.2.1 Discuss areas of human health treatment and diagnosis modified or affected by biotechnology products and processes

19.2.2 Compare current methods of breeding with methods of molecular genetic engineering

19.2.3 Discuss how biotechnologies impact crop and plant agriculture and forestry
19.2.4 Describe how biotechnological processes impact food production
19.2.5 Describe pharmaceutical company use of monoclonal antibodies
19.2.6 Discuss applications of biotechnologies in waste removal and cleanup, bioremediation, decontaminating soils, removing organic pollutants from industrial effluents, treating petroleum sludge and oil spills
19.2.7 Project applications of biotechnology to solve health problems

Unit 20: Technical Writing and Documentation

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 20.1: Evaluate technical writing requirements

Key Indicators:
20.1.1 Define/prioritize communication needs
20.1.2 Resolve conflicting requirements
20.1.3 Specify project objectives
20.1.4 Determine the size and specifics of the work to be completed
20.1.5 Estimate time, materials, and capabilities needed to complete assignment
20.1.6 Identify criteria for successful completion of project
20.1.7 Evaluate strengths and weaknesses of completed project

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 20.2: Write technical reports

Key Indicators:
20.2.1 Determine audience
20.2.2 Access needed information using standard references and sources
20.2.3 Identify type of report needed
20.2.4 Compile relevant data
20.2.5 Organize data into charts and graphs
20.2.6 Analyze data
20.2.7 Draw conclusions from data analysis
20.2.8 Outline report

20.2.9 Draft report
20.2.10 Edit report (e.g., check spelling, grammar, punctuation, sentence structure, accuracy of content)
20.2.11 Review report with peers
20.2.12 Revise report as needed based on peer feedback
20.2.13 Proofread revised report
20.2.14 Present reports

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 20.3: Conduct technical research

Key Indicators:
20.3.1 Identify target audience
20.3.2 Define research questions
20.3.3 Determine priorities for the information that should be gathered
20.3.4 Identify potential sources of information
20.3.5 Target audience/user group as a key information source
20.3.6 Identify subject-matter experts
20.3.7 Evaluate potential sources of information based on established criteria (e.g., affordability, relevance)
20.3.8 Conduct interviews with selection human information sources
20.3.9 Gather information from selected print and electronic sources
20.3.10 Determine the accuracy and completeness of the information gathered

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 20.4: Design technical documentation

Key Indicators:

20.4.1 Define purpose of documentation
20.4.2 Specify standards for documentation, including critical success criteria
20.4.3 Identify delivery options
20.4.4 Evaluate cost-effectiveness of each delivery option
20.4.5 Select tools appropriate for task purpose
20.4.6 Plan information flow
20.4.7 Select writing style and tone appropriate for given documentation
20.4.8 Determine level of detail needed
20.4.9 Identify visuals appropriate for given documentation
20.4.10 Provide feedback on design to development team/individual

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 20.5: Develop technical documentation

Key Indicators:

20.5.1 Determine audience
20.5.2 Identify parameters
20.5.3 Monitor development progress
20.5.4 Ask questions
20.5.5 Interpret specifications or drawings for target audience
20.5.6 Record process (e.g., flowchart, step-by-step narrative)
20.5.7 Record data

20.5.8 Maintain test logs
20.5.9 Compile cumulative reference/record
20.5.10 Measure compliance with established parameters
20.5.11 Verify the accuracy and validity of the information
20.5.12 Select information relevant to and appropriate for the given documentation
20.5.13 Organize/synthesize information
20.5.14 Present content in clear and concise way
20.5.15 Translate technical terminology into understandable terms (for audience)
20.5.16 Employ presentation tools and techniques appropriate for the given documentation
20.5.17 Obtain feedback on the information provided and its technical accuracy
20.5.18 Draft procedures
20.5.19 Test documentation for usability
20.5.20 Edit documentation for readability, grammar, and usage
20.5.21 Publish documentation
20.5.22 Maintain required logs
20.5.23 Track expenses

Unit 21: Computer Applications for Biotechnology

BIL: Essential

EDU:	12	AD	AC
	P		

Competency 21.1: Demonstrate basic computer literacy

Key Indicators:

21.1.1 Identify hardware and its use
21.1.2 Use hardware (e.g., printers, modems, touch screen, digitizers, plotters, graphic tablets, scanners, film recorders, video, laser image setters
21.1.3 Demonstrate basic care of hardware
21.1.4 Explain need for and application of security levels/procedures
21.1.5 Perform basic hardware troubleshooting
21.1.6 Explain hardware addressing techniques
21.1.7 Create directories/folders and sub-directories
21.1.8 Format disks
21.1.9 Manipulate files (copy, rename, delete)
21.1.10 Demonstrate proficiency in keyboarding skills

BIL: Essential

EDU:	12	AD	AC
	P		

Competency 21.2: Create documents using word processing software

Key Indicators:

21.2.1 Retrieve existing documents
21.2.2 Create documents using existing forms and templates
21.2.3 Safeguard documents using name and save functions
21.2.4 Format text using basic formatting functions

21.2.5 Check documents using print preview functions
21.2.6 Locate/replace text using search and replace functions
21.2.7 Create new word processing forms, style sheets, and templates
21.2.8 Employ word processing utility tools
21.2.9 Create tables using table functions
21.2.10 Create columns using column functions
21.2.11 Create outlines
21.2.12 Create footnotes and endnotes
21.2.13 Create and run macros
21.2.14 Assemble documents using merge functions
21.2.15 Format text using advanced formatting features
21.2.16 Print materials using print functions
21.2.17 Verify accuracy of output
21.2.18 Edit documents
21.2.19 Assess needed information using help screens
21.2.20 Create and incorporate graphs into documents
21.2.21 Create and incorporate chromatograms/spectral data into documents
21.2.22 Create and incorporate formulas and equations into documents

BIL: Essential

EDU:	12	AD	AC
	P		

Competency 21.3: Create spreadsheets

Key Indicators:
21.3.1 Design a spreadsheet in accordance with specifications to aid in the collection, tabulation, synthesis and evaluation of the identified data
21.3.2 Create spreadsheets
21.3.3 Retrieve existing spreadsheets
21.3.4 Check spreadsheets using print preview function
21.3.5 Format spreadsheets
21.3.6 Perform calculations using formulas
21.3.7 Edit spreadsheets
21.3.8 Create charts and graphs from spreadsheets
21.3.9 Group worksheets

21.3.10 Delete within spreadsheets
21.3.11 Move/copy within spreadsheets
21.3.12 Input/process data using spreadsheet functions
21.3.13 Improve spreadsheet display using enhancement features
21.3.14 Protect data using spreadsheet protection features
21.3.15 Record and run macros
21.3.16 Troubleshoot spreadsheet problems
21.3.17 Resolve function errors as needed
21.3.18 Apply advanced spreadsheet formulas
21.3.19 Calculate linear regression and incorporate into spreadsheet
21.3.20 Plot linearity data and incorporate into spreadsheet
21.3.21 Plot calibration curves and incorporate into spreadsheet
21.3.22 Perform statistical analysis such as T-tests and RSD's
21.3.23 Create spreadsheet solutions to business problems
21.3.24 Use spreadsheets to track, summarize, and monitor trends and analytical data
21.3.25 Make "what if—" business decisions using spreadsheets as a tool
21.3.26 Save spreadsheets
21.3.27 Access needed information using online help features
21.3.28 Print spreadsheets

BIL: Essential

EDU:	12	AD	AC
	P		

Competency 21.4: Create databases

Key Indicators:
21.4.1 Explain terms used in database systems
21.4.2 Describe common functions of database systems
21.4.3 Design database in accordance with given specifications
21.4.4 Create a database table
21.4.5 Edit the design of a database table
21.4.6 Edit the content of a database table
21.4.7 Search a table to locate records
21.4.8 Sort data in a single field

21.4.9 Enter data using a form
21.4.10 Create/modify a form
21.4.11 Perform single- and multiple-table queries
21.4.12 Create calculated fields
21.4.13 Generate customized reports for database files
21.4.14 Process data using database functions (e.g., structure, format, attributes, relationships, and keys)
21.4.15 Locate/replace data using search and replace functions
21.4.16 Print forms, reports, and results of queries
21.4.17 Verify accuracy of output
21.4.18 Sort data using multiple-field sorts
21.4.19 Add/remove filters
21.4.20 Create multiple criteria expressions
21.4.21 Create adjoined files
21.4.22 Index files
21.4.23 Create subforms
21.4.24 Group data in reports
21.4.25 Create graphs
21.4.26 Alter the appearance of a form by adding objects or properties
21.4.27 Identify the relationship between database components
21.4.28 Design a database to meet the needs of an actual situation or business problem
21.4.29 Evaluate database design and functionality
21.4.30 Use bio-informatics tools and access biological databases
21.4.31 Use databases to track and manage data such as quality measures, analytical results, chemical inventory, consumer comments

BIL: Essential

EDU:	12	AD	AC
	P	R	

Competency 21.5: Demonstrate knowledge of the Internet

Key Indicators:
21.5.1 Identify the key characteristics of the Internet
21.5.2 Demonstrate knowledge of the ownership/administration of the Internet

21.5.3 Identify current issues related to the Internet
21.5.4 Identify services and tools offered on the Internet
21.5.5 Identify the specific strengths, weaknesses, and special features of available search engines
21.5.6 Demonstrate knowledge of bookmarks and their functions
21.5.7 Demonstrate knowledge of accepted Internet etiquette (netiquette)
21.5.8 Identify current uses and applications of the Internet
21.5.9 Demonstrate knowledge of the Transmission Control Protocol/Internet Protocol suite
21.5.10 Demonstrate knowledge of the Domain Name Server
21.5.11 Demonstrate knowledge of Simple Network Management Protocol
21.5.12 Demonstrate knowledge of Bootstrap and Dynamic Host Configuration Protocol
21.5.13 Demonstrate knowledge of the Address Resolution Protocol
21.5.14 Demonstrate knowledge of IP forwarding, encapsulation, and fragmentation
21.5.15 Demonstrate knowledge of Internet security issues
21.5.16 Identify available Internet security systems

BIL: Essential

EDU:	12	AD	AC
	P		

Competency 21.6: Access the Internet

Key Indicators:
21.6.1 Connect to the Internet
21.6.2 Test Internet connection
21.6.3 Demonstrate knowledge of the components of Internet software
21.6.4 Install Internet software
21.6.5 Explore browser features
21.6.6 Download free software upgrades and shareware from the Internet
21.6.7 Unpack files using compression software
21.6.8 Demonstrate acute awareness of virus protection techniques

BIL: Essential

EDU:	12	AD	AC
	P	R	

Competency 21.7: Utilize Internet services

Key Indicators:

21.7.1 Access business and technical information using the Internet
21.7.2 Select search engines to use
21.7.3 Select appropriate search procedures and approaches
21.7.4 Locate information using search engines and Boolean logic
21.7.5 Navigate web sites using software functions (e.g., Forward, Back, Go To, Bookmarks)
21.7.6 Evaluate Internet resources
21.7.7 Access library catalogs on the Internet
21.7.8 Access commercial, government, and education resources
21.7.9 Bookmark web addresses (URLs)
21.7.10 Download files from FTP archives
21.7.11 Communicate via e-mail using the Internet
21.7.12 Subscribe to mailing lists
21.7.13 Participate in newsgroups
21.7.14 Retrieve online tools
21.7.15 Download/convert Internet programming files
21.7.16 Install/configure web browser
21.7.17 Explore the multimedia capabilities of the World Wide Web
21.7.18 Add plug-ins and helpers to the web browser
21.7.19 Explore collaboration tools
21.7.20 Archive files
21.7.21 Compile a collection of biotechnology business sites

BIL: Essential

EDU:	12	AD	AC
	P	R	

Competency 21.8: Use a shared environment

Competency Builders:

21.8.1 List purposes of a network environment
21.8.2 Define electronic mail
21.8.3 Identify advantages and disadvantages of electronic mail
21.8.4 Describe impact of local & wide area networks on mail delivery
21.8.5 Compose electronic messages
21.8.6 Send electronic messages using appropriate format
21.8.7 List categories of electronic mail service
21.8.8 Transmit document using electronic mail system
21.8.9 Monitor electronic mail
21.8.10 Use networked environments
21.8.11 Search database for properties of materials
21.8.12 Conduct literature searches using a variety of on-line tools
21.8.13 Explain access, security, transmission and retrieval
21.8.14 Participate in electronic discussion groups
21.8.15 Use bio-informatics tools and access biological databases (e.g., BLAST, C-DART)

BIL: Essential

EDU:	12	AD	AC
	P	R	

Competency 21.9: Operate software packages for science technology

Key Indicators:

21.9.1 Use PowerPoint or other presentation software
21.9.2 Use BLAST and other such programs for biological data analysis
21.9.3 Run instrumental data systems

Unit 22: Database Administration – (Bioinformatics strand)

BIL: Essential

EDU:	12	AD	AC
	I/P	P	

Competency 22.1: **Apply databases to actual situations and business problems**

Key Indicators:

22.1.1 Derive database design from a workflow drawing or other requirement documents
22.1.2 Design a database to solve a business problem or other real-life problem situation
22.1.3 Identify the relationship between database components
22.1.4 Sort data on multiple fields
22.1.5 Add/remove filters
22.1.6 Create queries with multiple criteria
22.1.7 Join tables in a query
22.1.8 Enhance the design of a form
22.1.9 Create needed subforms
22.1.10 Group data in reports
22.1.11 Make a calculation on a report
22.1.12 Imbed data and graphics
22.1.13 Import data and graphics
22.1.14 Link data and graphics

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 22.2: Apply data modeling techniques

Key Indicators:
22.2.1 Interpret terminology associated with data models
22.2.2 Compare/contrast various data models
22.2.3 Analyze data models
22.2.4 Develop a data model to describe an application's data

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 22.3: Create conceptual data models

Indicators:
22.3.1 Analyze model requirements
22.3.2 Identify business entities and the relationships between them
22.3.3 Define data in an integrated data dictionary
22.3.4 Ensure that conceptual model includes tools to facilitate user access

BIL: Essential

EDU:	12	AD	AC
	I	I/P	

Competency 22.4: Validate conceptual data models

Key Indicators:

22.4.1 Present conceptual data model to client
22.4.2 Resolve issues with client
22.4.3 Secure client approval for model
22.4.4 Feed recommendations back into the modeling process
22.4.5 Document validation process

BIL: Essential

EDU:	12	AD	AC
		I/P	

Competency 22.5: Integrate conceptual data models with enterprise models

Key Indicators:

22.5.1 Ensure that conceptual model is consistent with enterprise model (e.g., entity names, relationships, and definitions)
22.5.2 Develop conceptual schema
22.5.3 Secure client approval for modifications in enterprise models

BIL: Essential

EDU:	12	AD	AC
		I/P	

Competency 22.6: **Reconcile conceptual models with appropriate-level process models**

Key Indicators:

22.6.1 Verify consistencies between models
22.6.2 Identify areas of overlap
22.6.3 Verify that data entities in process model have a corresponding entity data model
22.6.4 Document changes or modifications in either model

BIL: Essential

EDU:	12	AD	AC
		I/P	

Competency 22.7: **Create logical data models**

Key Indicators:

22.7.1 Map data model to a relational model
22.7.2 Identify attributes of model entities and relationships between them
22.7.3 Verify that logical model is consistent with conceptual model
22.7.4 Specify integrity constraints

BIL: Essential

EDU:	12	AD	AC
		I/P	

Competency 22.8: Distinguish unique identifiers

Key Indicators:
22.8.1 Document identifiers
22.8.2 Identify rationale for selection of identifiers
22.8.3 Validate identifiers with client

BIL: Essential

EDU:	12	AD	AC
		I/P	

Competency 22.9: Normalize data models

Key Indicators:
22.9.1 Normalize data models
22.9.2 Verify that data model matches specifications
22.9.3 Validate logical data model with client

BIL: Essential

EDU:	12	AD	AC
		I/P	

Competency 22.10: Reconcile conceptual models with lower process models

Key Indicators:

22.10.1 Verify consistencies between models
22.10.2 Identify areas of overlap
22.10.3 Verify that data entities in process model have a corresponding entity data model
22.10.4 Document changes or modifications in either model
22.10.5 Integrate logical data model with enterprise model

BIL: Essential

EDU:	12	AD	AC
		I/P	

Competency 22.11 Determine environment/platform for physical data models

Key Indicators:

22.11.1 Research potential environments/platforms
22.11.2 Identify platform capabilities and limitations
22.11.3 Select environment/platform based on technical, business, and skill information gathered
22.11.4 Secure approval of target environment/platform

BIL: Essential

EDU:	12	AD	AC
		I/P	

Competency 22.12: Identify backup and recovery requirements for physical models

Indicators:

22.12.1 Establish backup requirements consistent with corporate policy and business needs

22.12.2 Document established backup procedures

22.12.3 Control access to database to maintain security

BIL: Essential

EDU:	12	AD	AC
		I/P	

Competency 22.13: Identify model access requirements

Key Indicators:

22.13.1 Identify inputs, output, and volume of every user view

22.13.2 Categorize user views by type of transaction

22.13.3 Document access to data by type of access

22.13.4 Integrate access requirements with backup and recovery plan

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 22.14: Identify physical database characteristics

Key Indicators:
22.14.1 Identify name, type, and length of attributes
22.14.2 Employ table and file names that conform to naming conventions
22.14.3 Group/assign tables to disk files
22.14.4 Index files for performance and integrity
22.14.5 Verify that data types are consistent between attributes
22.14.6 Employ normalization and modeling as cross-checking techniques

BIL: Essential

EDU:	12	AD	AC
		I/P	

Competency 22.15: Reconcile physical design with processing requirements

Key Indicators:
22.15.1 Resolve conflicts between physical model and process model
22.15.2 Verify that data entities in process model have a corresponding entity data model
22.15.3 Document changes made to either model

Unit 23: Data Warehousing – (Bioinformatics strand)

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 23.1: **Demonstrate knowledge of basic data warehousing concepts**

Key Indicators:

23.1.1 Differentiate between traditional databases and data warehouses
23.1.2 Recognize importance of data warehouses and integration
23.1.3 Recognize that information is a competitive resource
23.1.4 Identify components of data warehouses (e.g., subject-oriented, integrated, time-variant, nonvolatile)
23.1.5 Identify the characteristics and uses of metadata
23.1.6 Define types of information (e.g., associations, sequences, classifications, clusters, and forecasting)
23.1.7 Demonstrate knowledge of data conversion techniques and functions
23.1.8 Identify types of programs and applications for data warehousing
23.1.9 Identify types of data mining tools (i.e., neural networks, decision trees, rule induction, and data visualization)
23.1.10 Define public summary data
23.1.11 Demonstrate knowledge of ethical issues of data warehousing

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 23.2: Apply ethical behaviors to data warehousing

Key Indicators:
23.2.1 Define appropriate security measures
23.2.2 Analyze the limitations of external data
23.2.3 Identify ethical uses of data
23.2.4 Define use of permanent detail data for legal or ethical purposes

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 23.3: Perform data entry and updating

Key Indicators:
23.3.1 Develop an entity-relationship diagram
23.3.2 Employ appropriate index or indices
23.3.3 Define data repositories
23.3.4 Design metamodel
23.3.5 Apply appropriate security measures
23.3.6 Differentiate between permanent detail data and regular data
23.3.7 Apply skill in working with data programs
23.3.8 Maintain metadata
23.3.9 Size data warehouse
23.3.10 Load/transfer data (map data)
23.3.11 Scrub/filter data

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 23.4: Perform data retrieval

Key Indicators:

23.4.1 Locate appropriate data warehouses
23.4.2 Perform strategic analyses using a multidimensional database
23.4.3 Secure necessary indices
23.4.4 Design reasonable query
23.4.5 Define nature of application
23.4.6 Apply appropriate security measures
23.4.7 Obtain necessary responses from data query
23.4.8 Calculate derived and aggregate data
23.4.9 Validate the processing of data

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 23.5: Apply data

Key Indicators:

23.5.1 Optimize query procedures
23.5.2 Evaluate information gathered in query
23.5.3 Utilize public summary data
23.5.4 Design reporting medium
23.5.5 Perform online analytical processing
23.5.6 Construct report from data gathered

Unit 24: Statistics - (Bioinformatics strand)

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 24.1: **Demonstrate knowledge of the role of statistics and probability**

Key Indicators:

24.1.1 Identify the role of statistical methods in decision-making
24.1.2 Recognize the pervasive use of probability in the real world
24.1.3 Demonstrate knowledge of how to make predictions based on exponential or theoretical probabilities
24.1.4 Establish procedures for the systematic collection, organization, and use of data
24.1.5 Recognize the importance of using tables, charts, and graphs to organize and present data

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 24.2: **Make frequency distributions**

Key Indicators:

24.2.1 Demonstrate knowledge of the characteristics and uses of grouped and ungrouped frequency distributions
24.2.2 Make ungrouped frequency distributions using raw data
24.2.3 Make grouped frequency distributions using raw data
24.2.4 Interpret frequency distributions

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 24.3: Present data graphically

Key Indicators:

24.3.1 Demonstrate knowledge of the characteristics and uses of various tools for presenting data graphically
24.3.2 Prepare line charts/frequency polygons
24.3.3 Interpret line charts/frequency polygons
24.3.4 Prepare bar charts/histograms
24.3.5 Interpret bar charts/histograms

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 24.4: Apply measures of central tendency

Key Indicators:

24.4.1 Define mean, median, mode
24.4.2 Compute means, medians, and modes
24.4.3 Interpret measures of central tendency
24.4.4 Determine when and how to use measures of central tendency

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 24.5: Explain measures of dispersion

Key Indicators:

24.5.1 Define variance, average deviation, standard deviation, and coefficient of variation

24.5.2 Compute variance average deviations, standard deviations, and coefficients of variation

24.5.3 Interpret measures of dispersion

24.5.4 Determine when and how to use measures of dispersion

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 24.6 Solve probability problems

Key Indicators:

24.6.1 Define joint, marginal, and conditional probabilities

24.6.2 Solve joint probability problems using additions, multiplication permutation, and combination formulas

24.6.3 Solve marginal probability problems using additions, multiplication permutation, and combination formulas

24.6.4 Solve conditional probability problems using additions, multiplication permutation, and combination formulas

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 24.7 Apply binomial and normal probability distributions

Key Indicators:

24.7.1 Demonstrate knowledge of the characteristics and uses of normal probability distributions
24.7.2 Make binomial probability distributions
24.7.3 Make normal probability distributions

BIL: Essential

EDU:	12	AD	AC
	I	P	

Competency 24.8 Demonstrate knowledge of statistical inference

Key Indicators:

24.8.1 Demonstrate knowledge of the purposes of sampling
24.8.2 Demonstrate knowledge of standard methods for selecting a sample
24.8.3 Select a sample using an appropriate method
24.8.4 Demonstrate knowledge of the characteristics/uses of hypothesis testing
24.8.5 State a hypothesis
24.8.6 Test a hypothesis

APPENDICES

Appendix A

Biotechnology Profile Review Panel Participants

Debra Baker, Associate Director, Gene Screen

Bill Busby, Manager, Human Resources, Athersys, Inc.

Teresa A. Castle, Specialist, Analytical R&D, Mead Central Research Laboratories

Alan Coe, President/CEO, Paraspinal Diagnostic Corp.

Bryan Conn, Manager, Cancer Research Laboratories, The Rogosin Institute

Chris Cordle, Manager, Immunology R&D, Ross Products Division, Abbott Laboratories

Paul DeMasi, Manager, Human Resources, Alkermes, Inc.

Joseph Dietz, Director, QC/QA, ICN Biomedical

Patricia Eisenhardt, Vice President, ChipRx, Inc.

Lynn E. Elfner, CEO, The Ohio Academy of Science

Evan Facher, Manager, Business Development, Athersys, Inc.

Paula Gregory, Assistant Professor/Director, Outreach & Education, Human Cancer Genetics/OSU

Paul J. Grothaus, Director, Client Services & Marketing, Battelle Memorial Institute

Tim J. Huffner, The Proctor & Gamble Co, Miami Valley Labs

Cindy Karger, Tech Prep Director, Cuyahoga Community College

Ron Kindell, Tech Prep Director, Sinclair Community College

Dennis W. King, President, STATKING Consulting Inc.

Dave McDaniel, Biotechnology Pathway Manager, Sinclair Community College

Adel Mikhail, Vice President, Marketing & Development, LabBook.com Inc.

K. Megan O'Neill Miller, Chief Operating Officer, ChanTest, Inc.

Kunthavi Natarajan, Associate Professor, Biotechnology Program, Sinclair Community College

Denise S. Richardson, Technology Liaison, Northern Ohio, Edison Biotechnology Center, Inc.

Jack Steinicke, Tech Prep Director, Lakeland Community College

Ray Timlin, Tech Prep Director, Kent State University/Trumbull Campus

William D. Timmons, Senior Project Engineer, BIOMEC Systems, Inc.

Phyllis Williams, Biology Department Chair, Sinclair Community College

C. Ron Wilson, Senior Program Manager, Applied Biotechnology, Cognis Corp.

Business and education partners of:

Lakeland Community College
Sinclair Community College
Kent State University/Trumbull Campus
Cuyahoga Community College

Appendix B

PATHWAY TEMPLATE

(High School)

(Career Center)

(Community College)

Tech Prep Program

(School Year)

9th GRADE	CREDIT	10th GRADE	CREDIT	11th GRADE	CREDIT	12th GRADE	CREDIT

Recommended Prerequisites for Grade 11 of Tech Prep	Recommended for College Portion of Tech Prep

Junior Year Tech Center/College Technical Courses		Senior Year Tech Center/College Technical Courses	
*Technical Subjects	On-transcript ____ College Credits	*Technical Subjects	____ College Credits

Articulated Credits: - Community College

Revised 2/11/02

DEGREE: ASSOCIATE OF _____

_____ (Career Center) **-Tech Prep** _____ (Name of Tech Prep Program)

Term Taken	First Term	Pre-requisite	Co-requisite	Quarter Credit Hours	University Pathway Equivalent	Completed as Tech Prep Component
Term Taken	**Second Term**	**Pre-requisite**	**Co-requisite**			
Term Taken	**Third Term**	**Pre-requisite**	**Co-requisite**			

Revised 2/11/02

DEGREE: ASSOCIATE OF _____

_____-Tech Prep _____
(Career Center) (Name of Tech Prep Program)

Term Taken	Fourth Term	Pre-requisite	Co-requisite	Quarter Credit Hours	University Pathway Equivalent	Completed as Tech Prep Component

Term Taken	Fifth Term	Pre-requisite	Co-requisite			

Term Taken	Sixth Term	Pre-requisite	Co-requisite	Quarter Credit Hours	University Pathway Equivalent	Completed as Tech Prep Component

120

Revised 2/11/02

_____ **Total Quarter Credit Hours**

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